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Seasonal variability and Interactions among zooplankton in low-lying stream of J&K state, India

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Abstract
Seasonal succession and population dynamics of zooplankton communities is a well-documented phenomenon in an aquatic ecosystems. In this pretext, investigations on zooplankton diversity and density along with the interactive behaviour among various groups of zooplankton was carried out for a period of one year in unexplored and aesthetically important stream flowing through the heart of city. Qualitatively, 35 taxa of zooplankton belonging to 4 different groups viz. Protozoa, Rotifera, Copepoda and Cladocera were identified. Quantitatively, Protozoa showed dominance among the four groups indicating the deteriorating status of the water-body. Well-marked seasonal interaction among these groups were also witnessed in the present investigation.

Keywords: Zooplankton, Seasonal succession, Population dynamics, Interaction.

1. Introduction
Zooplankton, the free-swimming animalcules inhabiting different zones of aquatic ecosystems, provides valuable information about the ecological status of any water-body. Zooplankton have their own peak of rise and fall seasonally, depending upon various abiotic and biotic factors governing that water-body.
The success of a species in any water source depends on its ability to allocate and use the available resources of that water body. So, zooplankton, inhabiting any water body, are in frequent competition for resources and are also under heavy predation pressure in aquatic environment.
Thus is present varied diversity among water-bodies and also is much pronounced seasonal variability of zooplankton species. The communities of co-existing organisms may be present due to different niche requirements. So, the present study was under-taken to study the interactive and competitive status among the various components of zooplankton inhabiting this stream.

2. Material & Methods
Devika is a slow flowing stream running in the mid of city in the foothills of lower Shivaliks, between 32°53′27″N latitude and 75°6′34″E longitude. For present investigation, four different stations were selected with varying anthropogenic activities occurring there. First station has cremation site on its bank in addition to point of disposal of sewage. Second station is site for religious activities. Third station is a freshwater spring from which water is used for bathing and washing activities and the fourth station lying 10km away from Ist station has least anthropogenic influence bearing soft bottom and sparse marginal vegetation.

Collection of Zooplankton sample: Monthly samples for zooplankton study were collected for a period of one year (July, 2013-June, 2014). Collection was done by filtering 50 litres of water through plankton net (Nytex 70µm mesh size). The filtrate was transferred to glass vials and was preserved in 5% formalin. For the qualitative anlaysis, Edmondson & Winberg (1971) [5], Pennak (1978) [14] and Adoni (1985) [1] were referred. For quantitative analysis, the drop count method was applied and the number of zooplankton per litre of the concentrate was calculated by using the formula:

$$\textbf{Organism/litre} = A \times 1/L \times n/V$$

Where V = Volume of 1 drop (ml)
A = Number of organism per drop (ml)
n = Total volume of concentrated sample (ml)
L = Volume of original sample (l)

3. Results & Discussion

In the attempt of investigating invertebrates of Devika stream for a period of one year showed the presence of four zooplankton groups viz. Protozoa, Rotifera, Copepoda and Cladocera (Table I). Of these, maximum presence was recorded of Protozoa group being represented by 13 species belonging to 9 families. Group Rotifera was represented by 5 families, Cladocera by 2 families and Copepoda by 1 family. Of the four different stations located, the quantitative and qualitative pattern for zooplankton was varying. Station I, II & IV were having similar pattern of hierarchy of abundance for these four groups as Protozoa > Rotifera > Copepoda > Cladocera but Station III was having hierarchical sequence as Protozoa > Copepoda > Rotifera > Cladocera. Although there was presence of all the groups at all stations but within station, there appeared a well-marked fluctuation in presence and abundance of each of this group (Table II).

a) Protozoa: This group showed its abundance at all the four stations for the study period. Quantitatively, the total number of protozoans were highest at Station I (354.26 mg/l), followed by II (259.2 mg/l), IV (157.1 mg/l) and then III (114.04 mg/l). Protozoa showed peak value in summer season when there was recorded comparative fall in the number of rotifers at all the stations. This could be the reason for their summer peak. Less number of rotifers might be the reason for their higher number as rotifers act as predators of small protozoan species (Arndt, 1993) [2]. Their minimum value or sometimes absence during monsoon months might be due to reduced amount of food availability due to heavy rains and flooded conditions (Sharma, 2013) [15].

b) Rotifera: This group showed its abundance at Station I (77.24 mg/l), followed by II (42.16 mg/l), IV (11.52 mg/l) and then III (2.12 mg/l). They showed their maximum abundance during winters and contrary comparatively lower number of copepods were recorded at that time. Predation of copepods on rotifers is a known fact (Williamson, 1983 and Fussmann, 1996) [18, 7]. Further strengthening the correlation point is the presence of good number of Cyclopoid copepods at Station III where always lower abundance of rotifers was seen throughout the study period. Rotifers showed their minimum value or sometimes absence during monsoons which might be due to dilution of water resulting in lesser nutrients (Edmondson, 1965 & Sharma, 2013) [4, 15].

c) Copepods: This group showed its abundance at Station III (58.6 mg/l), followed by II (16.8 mg/l), I (9.26 mg/l) and then IV (3.78 mg/l). They showed their abundance during summer months because of optimal conditions for their flourishing (Heerkless *et al.,* 2005) [10]. Their minimum value or mostly absence during monsoons might be due to high water currents and other adverse conditions caused by floods during this period (Welcomme, 1975 & Ekpo, 2013) [17, 6]. Lower densities of Cylopoid copepods in winters may be associated with phenomenal characterisitics of copepods, the diapause (Maier, 1994) [12]. Another reason for their lower winter count can be the competition with rotifers for food and space (Badsi *et al*., 2010) which is under effect of low temperature and low food availability, which can affect female fertility and mortality of adults (Edmondson, 1965 and Patil & Panda, 2003) [4, 13].

d) Cladocera: This group showed its abundance at Station I (1.44 mg/l), followed by II (0.38 mg/l), IV (0.28 mg/l) and then III (0 mg/l). They showed their abundance during summers which could be due to conducible environment available for flourishing and lesser number of rotifers as they both (Cladocerans and rotifers) feed on similar algal types (Gilbert, 1988) [8]. Their absence during monsoons might be due to rapid water current and the increased turbidity which may cause loss of food availability and sustainable environment (Viroux, 2002 & Sharma, 2013) [16, 15]. The total absence of cladocerans at Station III, where copepods are abundant may be again due to predaceous nature of cyclopoid copepods on Cladocerans (Kerfoot, 1977; Gliwicz & Umana, 1994 and Becker *et al.,* 2004) [11, 9, 3].

4) Conclusion: In the present study, were recorded 35 taxa of zooplankton belonging to 4 groups viz Protozoa, Rotifera, Copepoda and Cladocera showing well-marked variations both quantitatively and qualitatively. From the detailed investigations, there were recorded interactions of both positive and negative capacity. Negative interaction was there as Copepods showed inverse relationship with cladocerans and rotifers because lesser number of Cladocerans and rotifers were present when comparatively more copepods were there. Differential peak seasons highlighting negative relation as when rotifers were high, protozoans were less. In this preliminary attempt, certain positive correlation was recorded as the coexistence of Rotifer *Philodina* and Protozoan *Vorticella* throughout the study period.

5. Acknowledgement

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Table I: Showing presence of different genera of zooplankton at different stations

S. NO.	Genus \ Stations	Station I	Station II	Station III	Station IV
1	*Centropyxis aculeate* (Ehrenberg, 1838)	+	+	+	+
2	*Centropyxis ecornis* (Ehrenberg, 1841)	+	+	+	+
3	*Centropyxis hemispherica*	-	-	-	+
4	*Euglypha sp.*(Dujardin, 1841)	-	+	-	-
5	*Bursaridium sp.*(Lauterborn, 1894)	+	+	-	+
6	*Paramecium aurelia* (Ehrenberg, 1831)	+	+	-	+
7	*Paramecium caudatum* (Ehrenberg, 1834)	+	-	-	-
8	*Paramecium trichium* (Stokes, 1885)	+	+	-	-
9	*Epistylis sp.*(Ehrenberg, 1831)	+	+	-	+
10	*Colpidium sp.*(Stein, 1860)	+	+	+	+
11	*Euplotes sp.*(Ehrenberg, 1830)	-	-	-	+

12	*Campanella sp.*	-	+	-	-
13	*Vorticella sp.* (Ehrenberg, 1838)	+	+	+	+
14	*Philodina sp.*(Hickernell, L.M., 1971)	+	+	+	+
15	*Philodinavus paradoxus* (Murray, 1905)	+	+	+	+
16	*Rotaria sp.* (Scapoli, 1777)	-	+	-	-
17	*Trichocerca multicrinis* (Kellicott, 1897)	-	-	-	+
18	*Euchlanis sp.* (Ehrenberg, 1832)	+	+	-	+
19	*Asplanchna sp.* (Gosse, 1850)	+	+	-	+
20	*Tropocyclop prasinus* (Fischer, 1860)	+	+	+	+
21	*Macrocyclop albidus* (Jurine, 1820)	+	+	+	+
22	*Macrocyclop sp.*	+	+	+	+
23	*Cyclop magnus* (Marsh, 1920)	+	-	+	-
24	*Cyclop scutifer* (Sars, 1863)	+	+	+	
25	*Cyclop bicolor* (Sars, 1863)	+	-	-	-
26	*Cyclop panamensis* (Marsh, 1913)	-	+	-	-
27	*Mesocyclop leukartii* (Claus, 1857)	-	+	-	-
28	*Mesocyclop tenuis (*Marsh, 1909)	+	+	+	+
29	*Halicyclop sp.* (Linderberg, 1957)	+	+	+	-
30	*Eucyclop sp.* (Claus, 1893)	+	-	-	-
31	*Nauplius larva*	+	+	+	+
32	*Chydorus sp.* (Leach, 1843)	+	+	-	-
33	*Ceriodaphnia sp.* (Dana, 1853)	+	+	-	-
34	*Daphnia sp.* (O.F.Muller, 1785)	+	-	-	-
35	*Alona sp.* (Birge, 1891)	-	+	-	+

Note: "+" indicates presence of organism
"–" indicates absence of organism.

Table II: Showing the seasonal variation in zooplankton community at different stations

Station I												
Months / Groups	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Protozoa	-	-	0.2	29.16	22.6	16.84	29.8	22.74	48.64	15.00	98.00	71.28
Rotifera	-	-	1.28	3.48	19.54	12.86	16.82	3.52	8.8	6.18	2.36	2.4
Copepoda	-	-	-	-	0.42	1.52	0.04	0.18	0.3	3.38	2.18	1.24
Cladocera	-	-	-	-	-	-	0.30	0.28	-	0.22	0.24	0.40
Station II												
Protozoa	-	-	0.4	0.8	0.44	9.1	41.38	26.78	72.22	15.68	55.22	37.18
Rotifera	-	-	-	-	10.28	4.22	9.32	3.18	2.14	2.84	3.26	6.92
Copepoda	-	-	-	-	-	-	0.1	0.74	0.18	2.12	7.5	6.16
Cladocera	-	-	-	-	-	-	0.04	0.1	0.08	0.16	-	-
Station III												
Protozoa	0.1	-	-	0.28	0.66	0.48	11.68	1.26	4.00	6.2	33.86	55.52
Rotifera	0.04	0.02	-	0.08	0.12	0.08	0.08	0.64	0.12	0.16	0.46	0.32
Copepoda	-	-	-	1.38	6.18	5.9	11.7	4.66	3.42	4.28	8.26	12.82
Cladocera	-	-	-	-	-	-	-	-	-	-	-	-
Station IV												
Protozoa	-	-	-	-	0.34	0.28	0.76	2.36	59.7	32.00	27.9	33.76
Rotifera	-	-	-	-	0.74	3.02	1.00	1.38	1.3	0.9	2.3	0.88
Copepoda	-	-	-	-	0.06	0.3	0.42	0.2	-	1.5	0.42	0.88
Cladocera	-	-	-	-	-	-	0.06	-	0.06	0.16	-	-

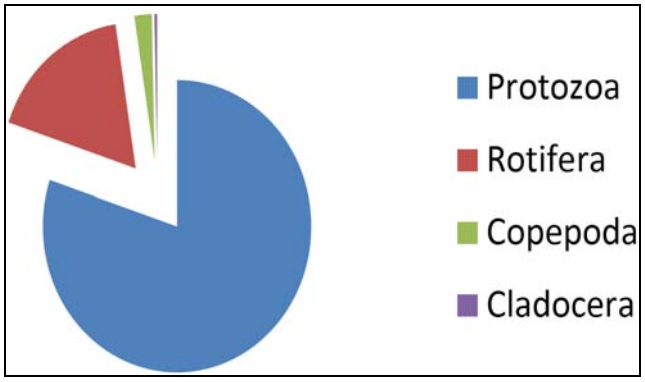

Fig III: Showing abundance of zooplanktonic groups at Station I

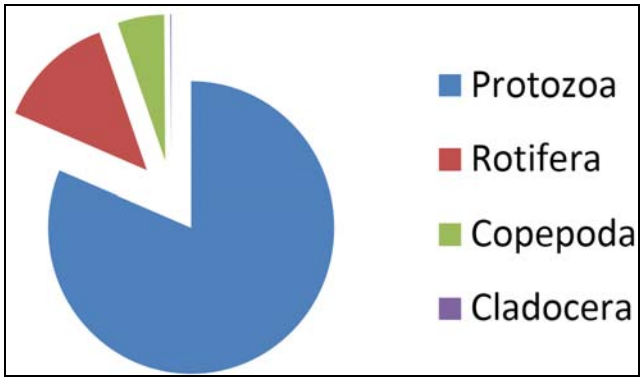

Fig IV: Showing abundance of zooplanktonic groups at Station II

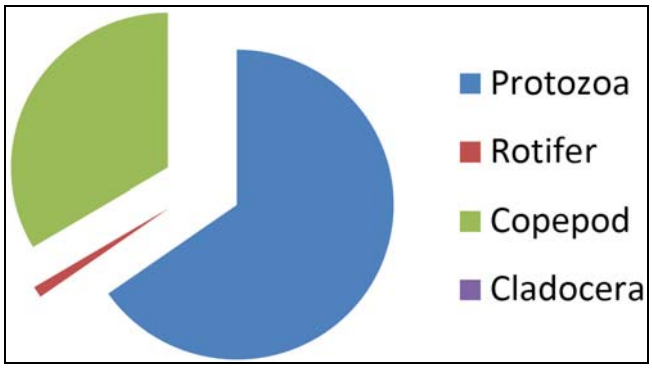

Fig V: Showing abundance of zooplanktonic groups at Station III

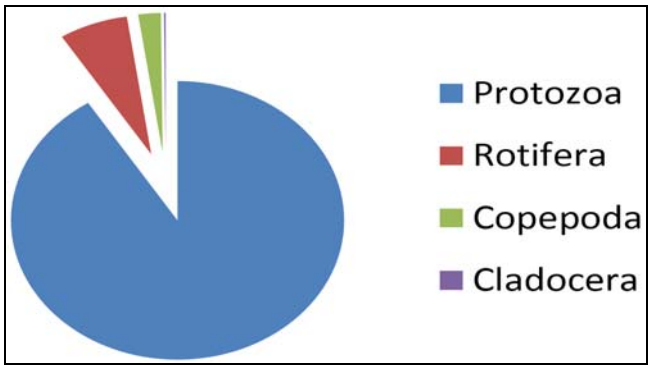

Fig VI: Showing abundance of zooplanktonic groups at Station IV

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